

Strategies for Energy Benchmarking in Cleanroom and Laboratory-Type Facilities

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Context of LBNL Benchmarking Project

LBNL High-Tech Buildings Initiative
... Headed by The Applications Team

Many Components

- *Benchmarking*
(ongoing; w/PG&E)
- *Design Guide, Design Intent Tool*
(ongoing; w/CIEE, CEC)
- *Roadmap*
(upcoming; w/CEC)
- *High-Performance Fume Hood*
(prototype/ongoing; w/CIEE, CEC, PG&E, DOE, MSU)



See Existing Resources
<http://ateam.lbl.gov>

Overview

What is benchmarking?

Why perform benchmarking?

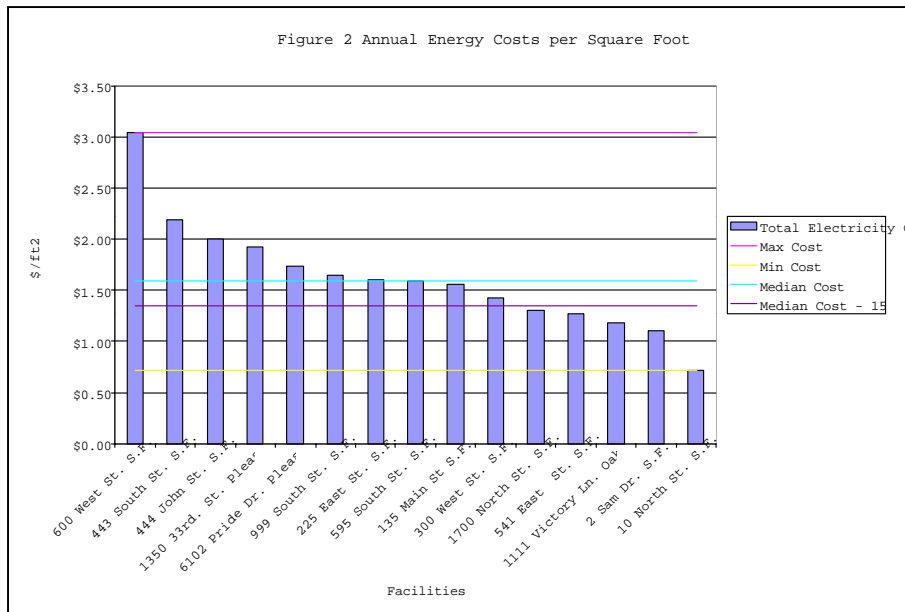
**Why cleanrooms and
laboratory-type facilities?**

Project status/activities

What's next?



What Is Energy Benchmarking?



Sample benchmarking study by PG&E

Comparison of:

...whole building

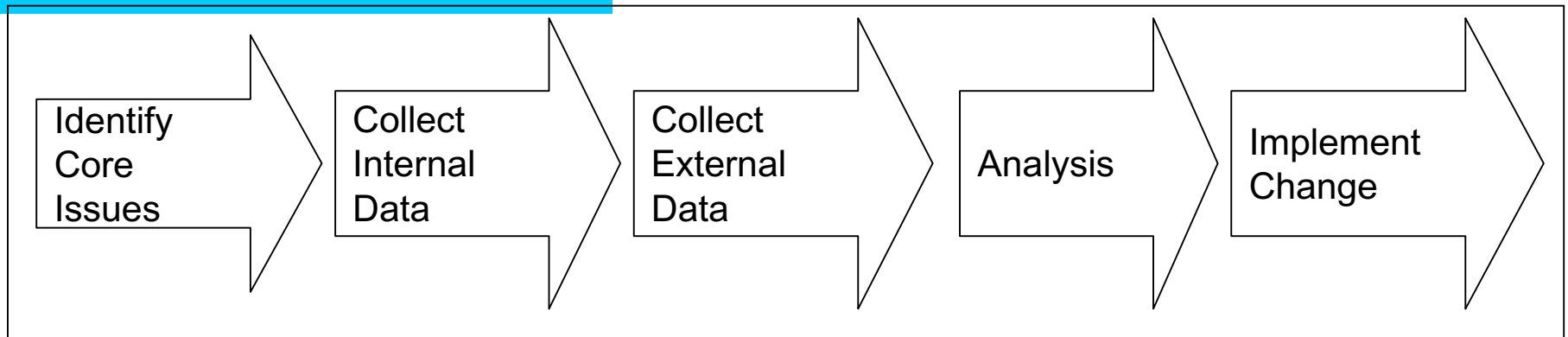
...specific system

...specific component
to a comparable data set

Why Perform Energy Benchmarking?

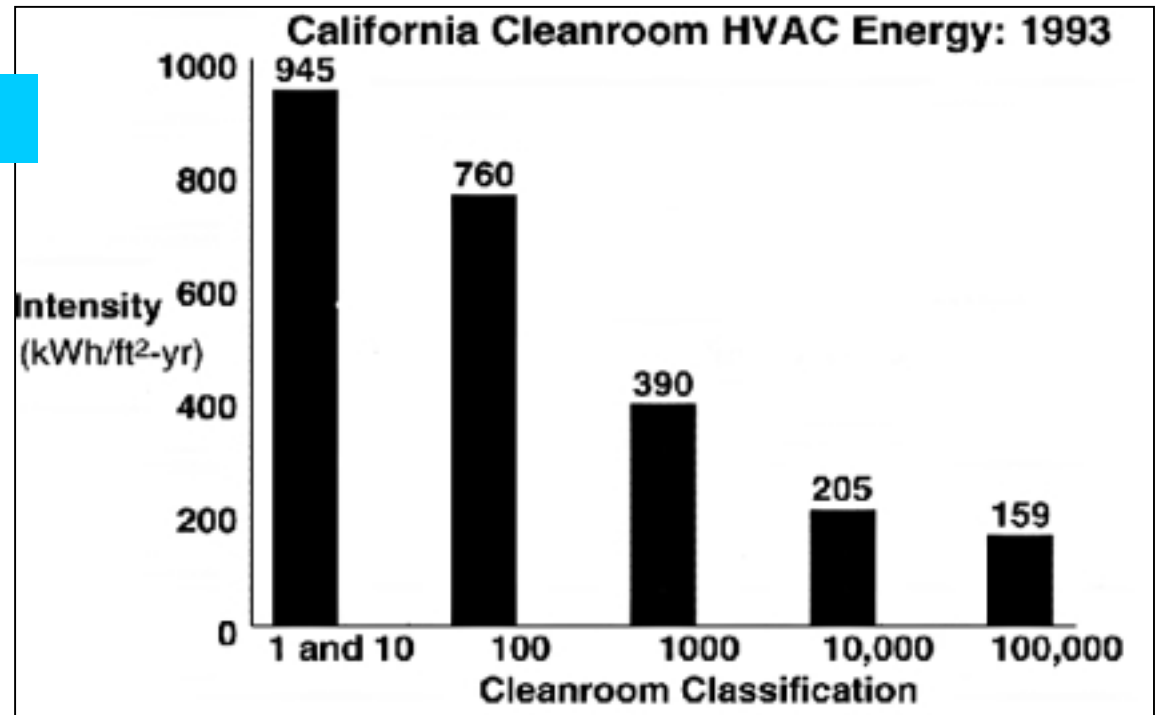
- ✓ Total Quality Management (TQM)
- ✓ Compare performance to others
- ✓ ID process improvement opportunities

Benchmarking Framework



Why Cleanrooms and Lab-Type Buildings?

Very energy intensive



High energy-use characteristics

- High air flows/exhaust rates
- Strict filtration needs
- Tight temperature/humidity requirements

Why Cleanrooms and Lab-Type Buildings?

High Energy-Savings Potential
...perhaps 50%



Opportunities

- Integrated design
- High-performance design characteristics
- Operations improvements
- Commissioning

Benchmarking Issues—Cleanroom Facilities

Traditional measures inadequate

...kWh/sq-ft and Btu/sq-ft don't address process energy

Mixed use

...process loads create widely varying power densities

...range of cleanliness classes = varying energy use



Summary—inadequate metering complicates analysis

Benchmarking Techniques

- 1. Statistical Analysis**
...compare energy-use intensities
- 2. Point-Based Rating**
... assign ratings by bldg. characteristics
- 3. Model-Based Rating**
...develop "effectiveness metric"
- 4. Hierarchical End-Use Performance Metrics**
...develop hierarchical performance metrics
- 5. Hybrid**
...combination of others



Key Issue—selecting and defining metrics

Statistical Benchmarking

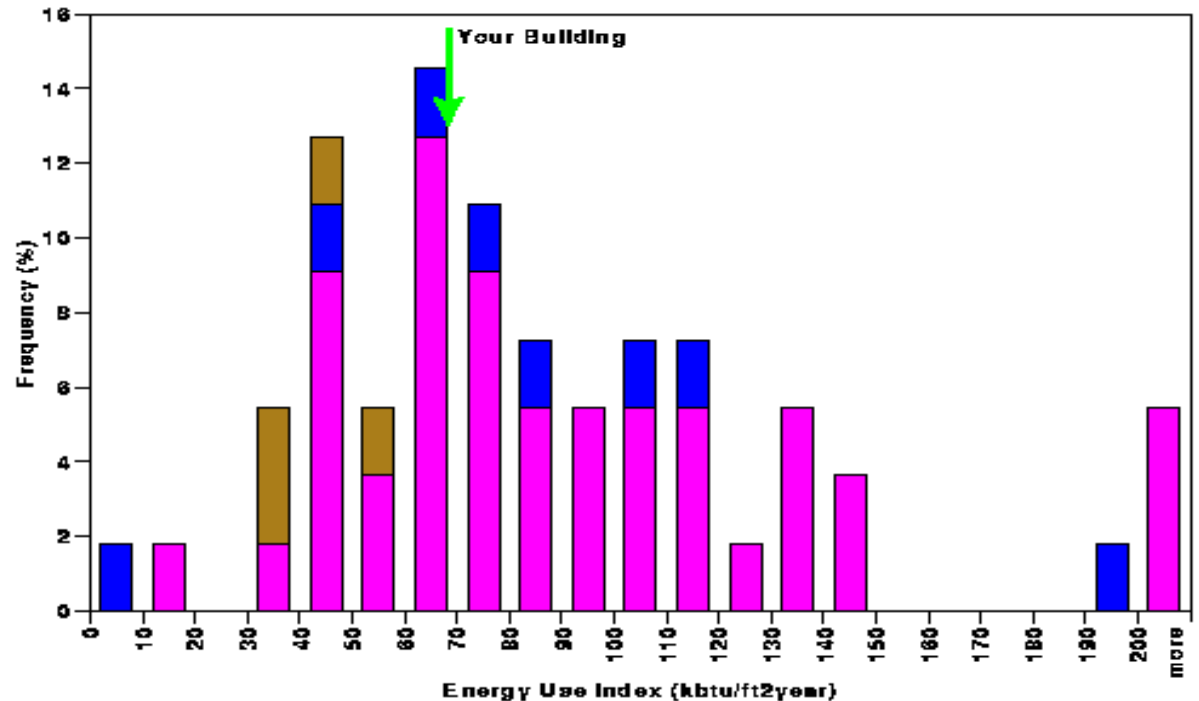
U.S. DOE EIA

...extensive building energy-use database

LBNL Tool

Input → bldg. size, type, & energy use

Output → EUI histogram



EUI Benchmarking Plot from LBNL tool
(available at <http://gismo.lbl.gov/arch/>)

U.S. EPA Energy Star Building Rating

...top 25% = star rating

...foundation = EIA analysis

...www.epa.gov/buildings/label/html/benchmarking.html

Office bldgs only—for now

Point-Based Benchmarking

Example → LEED

Leadership in Energy and Environmental Design

www.leedbuilding.org

- Sponsored by U.S. Green Building Council
- Levels of green building certification... "credits" based
 - Energy efficiency
 - Erosion control
 - IAQ
 - Thermal comfort
 - Water conservation
- No quantitative comparison between buildings
- Better for new construction than on-going benchmarking

Model-Based Benchmarking

Developer

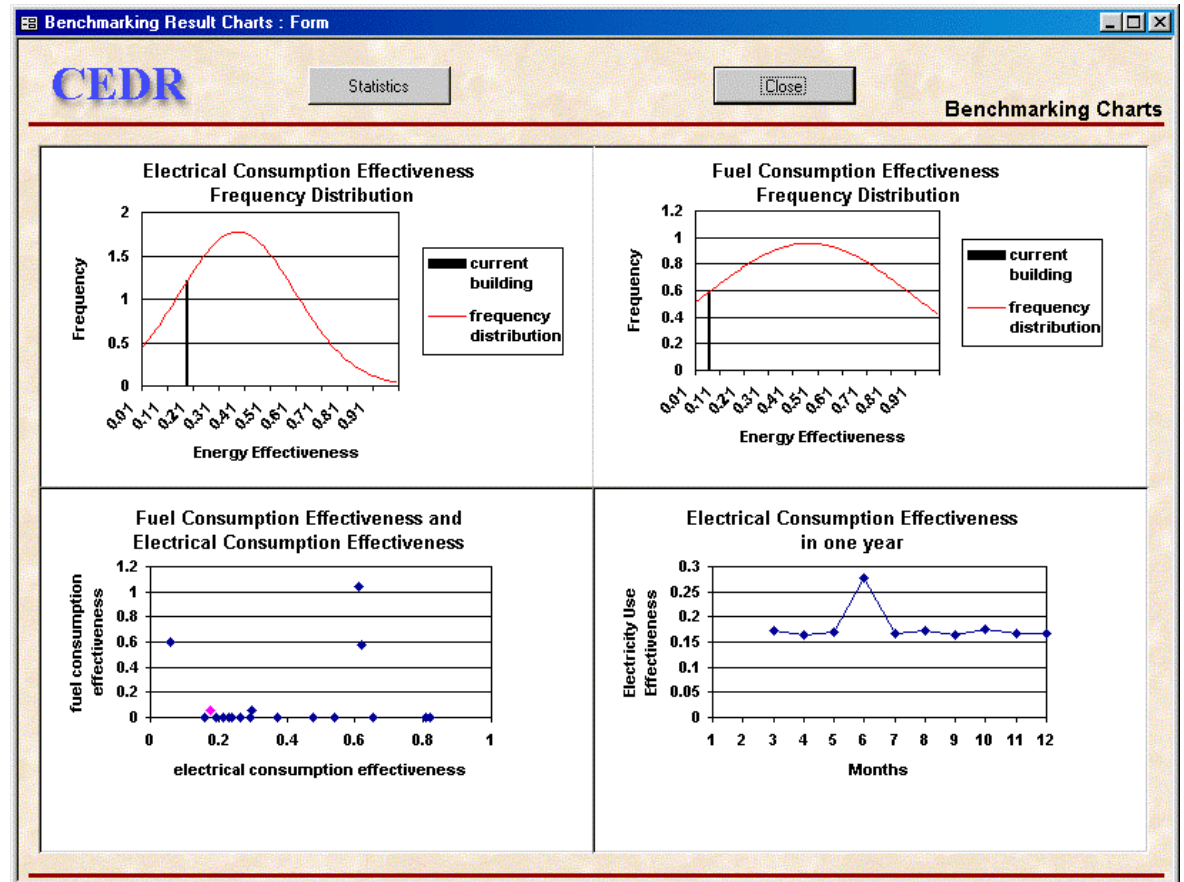
UC Center for
Environmental
Research (CEDR)

Issues Overcome

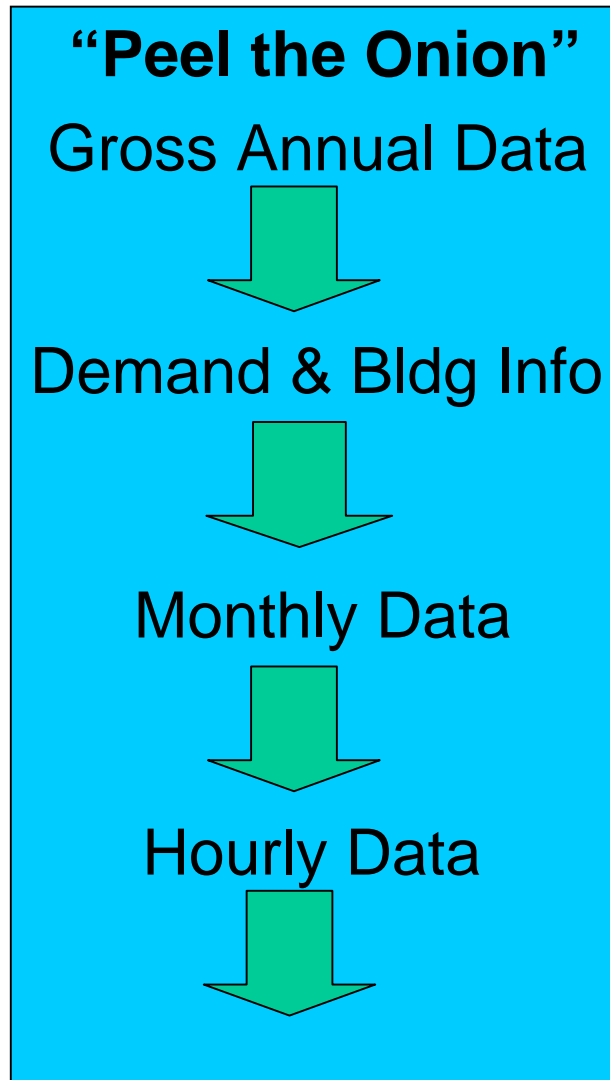
- Only compare similar buildings
- Entire building population inefficient?

Approach

- Calculate idealized minimum facility energy use
- Compare (actual building energy) / (theoretical building energy)



Hierarchical & End-Use Performance Metrics



- Develop performance metrics
- Begin at highest level and move down to subsystems
- Hierarchical approach useful
 - ID energy opportunities
 - Explain “false” signals

Hybrid Tools

Potential Approach to Develop Ideal Tool

- Combine best of all methods
- Three modules = effective screening
 - Whole-building data and metrics
 - End-use data and metrics
 - Performance rating
- Additional features
 - Multiple parameter visualization
 - Performance targets
 - Resources via Web links
 - Best practice case studies



Hybrid Tool

*Just an idea for now...
Anybody w/funding?*

Benchmarking Driving Force US Executive Order

Federal Laboratories → Cut energy use 25% by 2010 (re: 1990)

Issues Abound

- What is baseline energy?
 - Weather impacts
 - Variable process loads
 - Facility changes (schedule, size, etc.)
- Potential strategies
 - Submeter process loads
 - Statistical EUI comparison

Benchmarking Driving Force

EPA/DOE Initiative — Labs for the 21st Century

Develop/Provide

- *Voluntary energy performance goals*
 - ...likely whole-building w/o submetering
 - ...may combine statistical- & model-based methods
- *Recognition criteria*
 - ...points for efficient features
- *Laboratory energy management tools*
 - ...public & private laboratory applications



Web Address

www.epa.gov/labs21century/

Benchmarking Driving Force PG&E Market Transformation

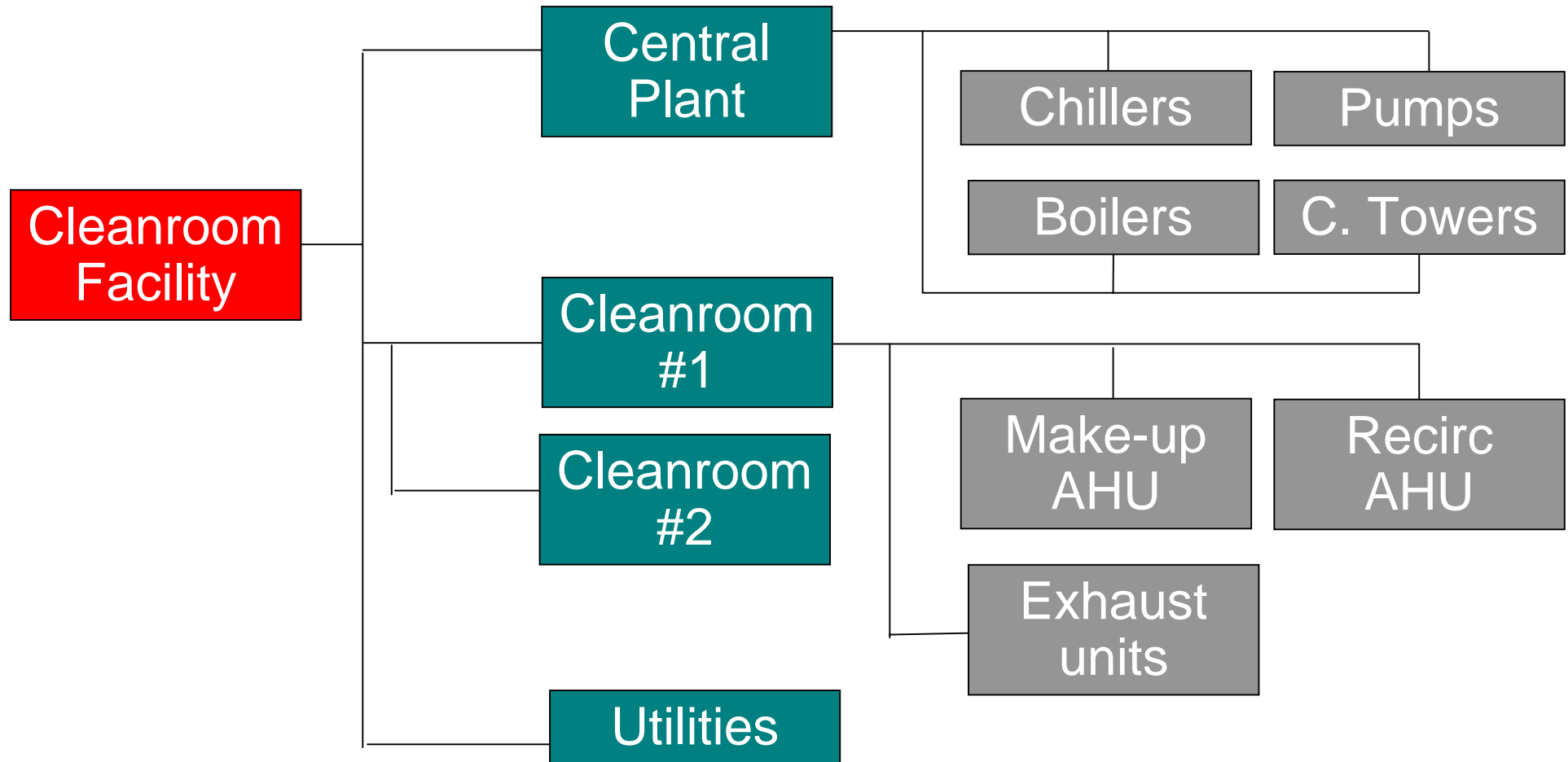
High-Tech Sector Benchmarking Research Recently Begun

- *Electronics & biotech*
 - ...large & growing CA presence

- *Objectives*
 - ...ID HVAC usage w/o process/other usage
 - ...ID best practices
 - ...establish benchmarks

- *Activities*
 - ...series of short-term measurements, several cleanliness classes

PG&E Cleanroom Benchmarking Database Schematic



Microsoft Access - [Cleanroom General Form : Form]

File Edit View Insert Format Records Tools Window Help



Building 3

Cleanroom Name: Class 10 Cleanroom

Cleanroom ID: 3

Facility ID: 6

Primary Cleanroom Area: 25600 sf

Secondary Cleanroom Area: 24700 sf

Building Area: 129000 sf

Class 1 to 10

Annual Hours Use: 8760 Hrs

Fan Type Pressurized Plenum

Heat Recovery ☐ Raised Floor ☒

Tolerance

Cleanroom Temperature: 68 °F ± 2 °F

Humidity Conditions: 50 % ± 5 %

Design Measured

Lighting Power: 46 46.1 kW

Process Power: 200 180 kW

Other Power: 60 kW

Ceiling Velocity: 90 fpm

Room Pressurization: 3 3.46 in. w.g.

Recirculation Air Exhaust Makeup Air

Recirculation Air Description:

Monitoring End Date: 6/15/2000

Monitoring Start Date: 6/29/2000

Makeup Air

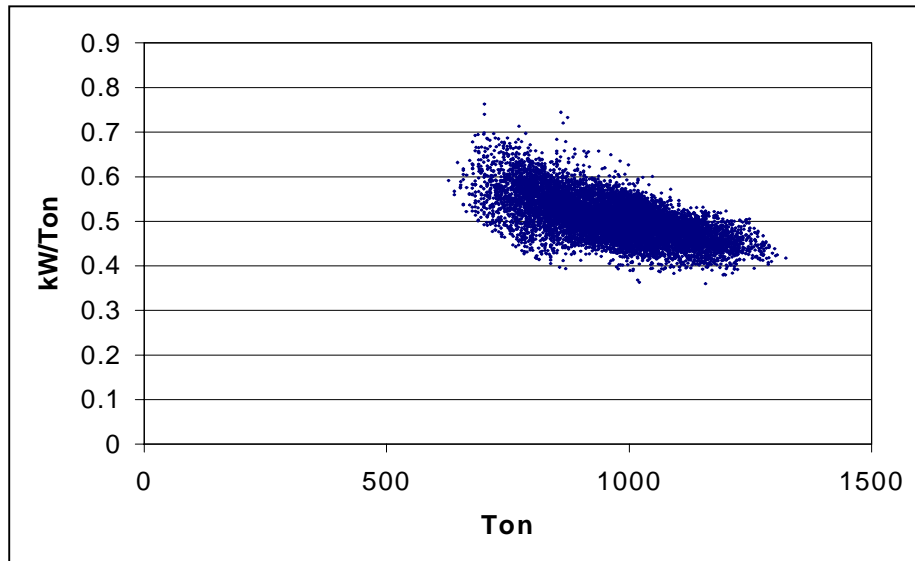
Recirc Air

Exhaust



PG&E Cleanroom Benchmarking

Sample Output—One Site



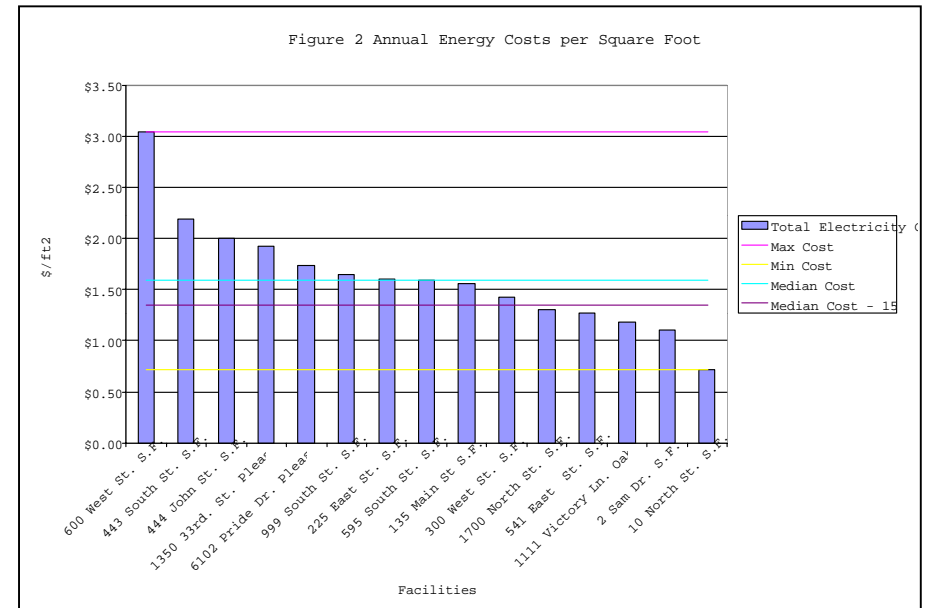
Chiller efficiency vs. load

Metric	Value
Chiller Efficiency	0.502 kW/ton
Plant Efficiency	0.689 kW/ton
Class 10 RCU	5,460 cfm/kW
Class 100 RCU	7,845 cfm/kW
Energy Cost	\$43.85/sq. ft.

Benchmarking Driving Force PG&E Market Transformation

Commercial Facility Benchmarking Services Recently Begun
www.pge.com/customer_services/business/energy/customnet

- *CustomNet for Big Business*
...comparisons inside & outside the organization
- *CustomNet for Small Business*
...comparisons to other owners' facilities
- *Data source*
...PG&E 1999 Commercial Building Survey



Sample benchmarking study by PG&E

Summary

Benchmarking a valuable tool

...growing interest across the country...across markets

Cleanrooms/Laboratories

...huge energy savings opportunities
...little benchmarking data available



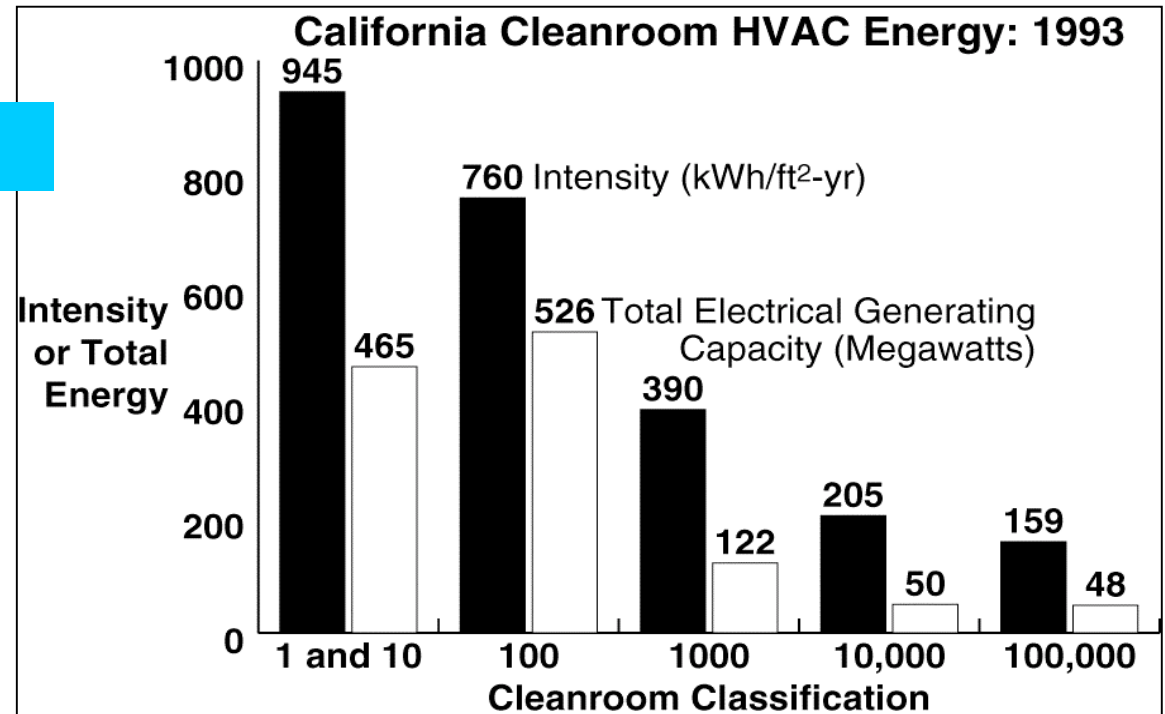
Stay Tuned!

More info coming from LBNL A-Team

<http://ateam.lbl.gov>

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